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MODEL 270
CAPACITANCE BRIDGE
INSTRUCTION MANUAL

Electro Scientific Industries
7524 S. W. MACADAM AVE. PORTLAND 19, OREGON

INSTRUCTION MANUAL

ESI Model 270
CAPACITANCE BRIDGE

ELECTRO SCIENTIFIC INDUSTRIES
7524 S. W. Macadam Ave.
Portland 19, Oregon

March 1957

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Catalog Sheet

BRIDGES AND ACCESSORIES

C-15

MARCH 1962
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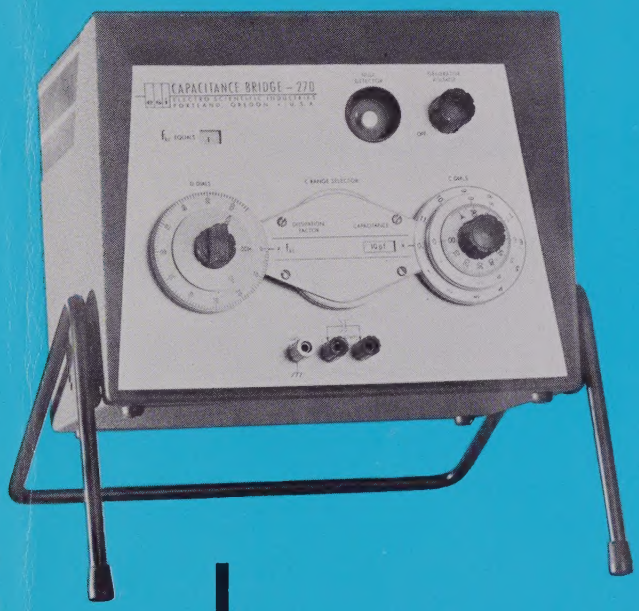

CAPACITANCE BRIDGE

MODEL 270

A wide-range, self-contained instrument offering 0.1% accuracy

The Model 270 Capacitance Bridge is a portable self-contained instrument for the rapid and accurate measurement of capacitance and dissipation factor over a wide range of values. The Model 270-L measures one decade of capacitance lower than the Model 270 and the Model 270-H measures one decade higher in both capacitance and dissipation factor.

No correction is necessary for zero capacitance within the bridge. The bridge has internal shielding which eliminates stray capacitance in parallel with the unknown. This feature makes possible measurements of small three-terminal capacitors to an accuracy of 0.01 micromicrofarads without the use of a separate guard circuit or Wagner ground. A shielded lead can be used to eliminate test lead capacitance.

The case and controls for this instrument have been "human-engineered" to provide the operator maximum accuracy with a minimum of effort. The exclusive ESI DEKADIAL® assembly provides direct in-line readings of capacitance and dissipation factor. The equivalent of 12,005 dial divisions of resolution are available on each capacitance range.

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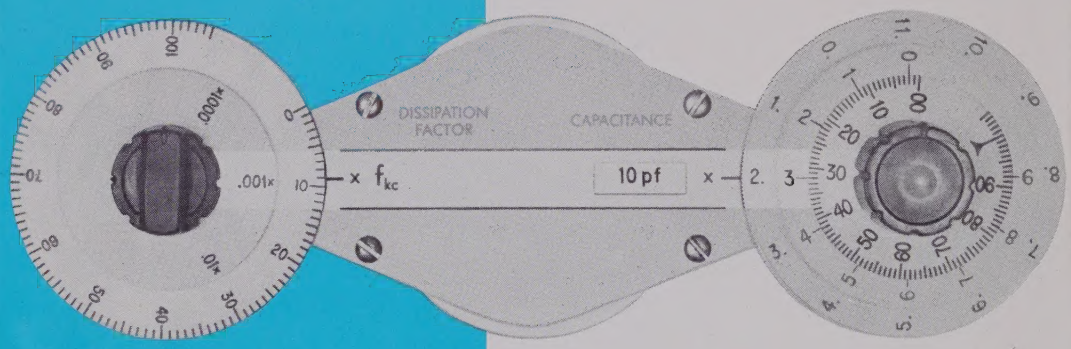
Capacitance Bridge

MODEL 270

The Model 270 Capacitance Bridge is a self-contained instrument. The generator and detector are integral parts so that the instrument is complete and ready to use. The detector is sharply tuned to minimize the effects of hum pickup and harmonic response. The frequency of operation is determined by a plug-in network. A 1 kilocycle network is supplied with the bridge and networks for other frequencies between 100 cycles and 10 kilocycles are available on special order. The frequency in use is indicated through a window in the front panel of the bridge.

Featuring the ESI DEKADIAL®



The unique patented ESI DEKADIAL® system of the Model 270 Capacitance Bridge provides unusual simplicity and convenience in reading. The capacitance readings are obtained from coaxial dials which operate two precision resistance decades in combination with an interpolating rheostat. The outer decade dials permit rapid scanning of the capacitance range when searching for an initial null, and the inner dial provides an interpolating adjustment for accurately locating the exact point of balance. The DEKADIAL® provides the equivalent of 12,000 dial divisions. The range multipliers for both capacitance and dissipation factor appear directly beside the main dials, presenting the readings clearly in decimal form in a single horizontal line. The reading illustrated above is D = 0.009, C = 23.32 pf.

Dual NULL INDICATOR

A dual electron-ray type null indicator is used. The upper pattern responds to large variations in signal and the lower pattern provides high sensitivity for reaching an accurate balance.

The ac signal is directly coupled to the electron deflection plates and gives a characteristic pattern as long as ac is present at the bridge detector terminals. This provides a display which shows clearly the difference between a minimum voltage and a true null. The null is indicated by a maximum opening of both patterns.

The sensitivity of the lower pattern can be adjusted by a control knob inside the case. The quick response of the electron ray indicator makes possible rapid limits testing by adjusting this sensitivity control to close the pattern at the tolerance limit.

Specifications

esi

MODEL 270

CAPACITANCE READINGS

NUMBER OF RANGES—Seven.
DIAL RESOLUTION—12,005 divisions full scale on any range.
HIGHEST RANGE—0 to 120 μf.
LOWEST RANGE—0 to 120 pf; 1 dial division represents 0.01 pf.
ACCURACY*—On the five intermediate ranges: ±(0.1% +1 dial division).
On highest range and lowest range: ±(0.2% +1 dial division).

DISSIPATION FACTOR READINGS

NUMBER OF RANGES—Three.
DIAL RESOLUTION—105 divisions full scale on any range.
HIGHEST RANGE—0 to 1.05 x frequency in kilocycles.
LOWEST RANGE—0 to 0.0105 x frequency in kilocycles; at 1 kc, 1 dial division represents a D of 0.0001.
ACCURACY*—±(2% +0.0005).

For applications requiring higher or lower capacitance ranges, the ESI Models 270-L (0.001 pf per division) and 270-H (1,200 μf max.) are recommended.

MODEL 270-H (HIGH RANGE)

Capacitance measurements to 1200 μf.

CAPACITANCE READINGS

HIGHEST RANGE—0 to 1200 μf.
LOWEST RANGE—0 to 1200 pf; 1 dial division represents 0.1 pf.
ACCURACY*—On the four intermediate ranges: ±(0.1% +1 dial division. On the two highest ranges and the lowest range: ±(0.2% +1 dial division).

DISSIPATION FACTOR READINGS

HIGHEST RANGE—0 to 10.5 x frequency in kilocycles.
LOWEST RANGE—0 to 0.105 x frequency in kilocycles; at 1 kc, 1 dial division represents a D of 0.001.

MODEL 270-L (LOW RANGE)

Capacitance measurements to 0.001 pf per division.

CAPACITANCE READINGS

HIGHEST RANGE—0 to 12 μf.
LOWEST RANGE—0 to 12 pf; 1 dial division represents 0.001 pf.
ACCURACY*—On the five intermediate ranges: ±(0.1% +1 dial division).
On highest range and lowest range: ±(0.2% +1 dial division).

DISSIPATION FACTOR READINGS

HIGHEST RANGE—0 to 0.105 x frequency in kilocycles.
LOWEST RANGE—0 to 0.0105 x frequency in kilocycles; at 1 kc, 1 dial division represents a D of 0.0001.

***NOTE:** Accuracy ratings apply at a frequency of 1 kc and a temperature of 25°C. Slightly larger errors may be encountered at frequency or temperature extremes. Capacitance accuracy specifications apply when the bridge has been recently standardized against a reference standard capacitor. The long-term drift in calibration will not exceed 0.1% per year, (0.2% for 270-H) and any such drift can be corrected by a single adjustment to restandardize the bridge against any certified reference standard capacitor.

GENERATOR-DETECTOR SPECIFICATIONS

FREQUENCY SELECTION—A single plug-in unit tunes both the generator and the detector.
STANDARD FREQUENCY—A 1 kc unit is supplied with the bridge.
SPECIAL FREQUENCIES—Any frequency between 100 cycles and 10 kc can be supplied on special order.
GENERATOR FREQUENCY ACCURACY— ±1%.
GENERATOR OUTPUT—Adjustable from 0 to approximately 15 volts, in series with an equivalent generator impedance of 500 ohms. For polarized capacitor measurements, an external dc voltage up to 300 volts may be connected.
DETECTOR INPUT—20 microvolt sensitivity at maximum gain; 0.5 megohms.
DETECTOR SECOND HARMONIC SUPPRESSION—At least 30 db.
DETECTOR OUTPUT DISPLAY—Dual-pattern electron-ray indicator. Wide dynamic range eliminates need for readjusting sensitivity as null is approached. Pattern sensitivity can be adjusted for use as a tolerance limit.
POWER SUPPLY—115 volts, 50/60 cycles, 30 watts input. (230 volts, 50/60 cycles on special order).
ACCESSORIES—No accessories required for operation at 1 kc.

PHYSICAL SPECIFICATIONS

The Models 270, 270-L and 270-H Capacitance Bridges are mounted in portable metal cases with adjustable legs. Models 270-R, 270-L-R and 270-H-R are available on special order for standard rack mounting.

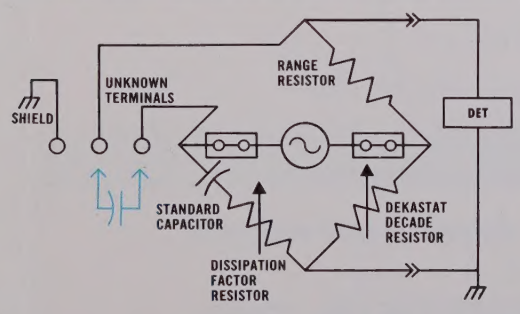
DIMENSIONS (in inches) . . . . . 11 W x 8½ H x 7½ D
NET WEIGHT . . . . . 19 Pounds
SHIPPING WEIGHT . . . . . 25 Pounds

Model 270
Price $575.00*

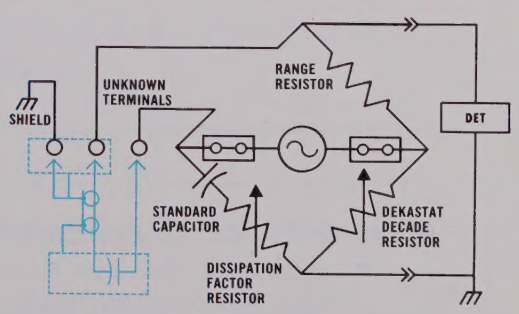
Model 270-H
Price $650.00*

Model 270-L
Price $650.00*

* f.o.b. Portland, Oregon



TWO-TERMINAL CAPACITANCE MEASUREMENTS

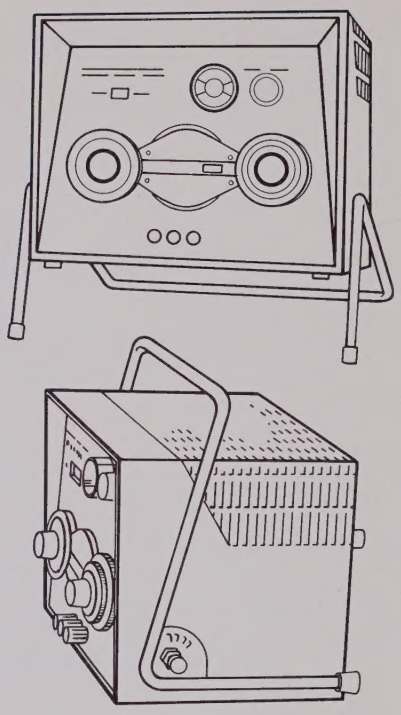


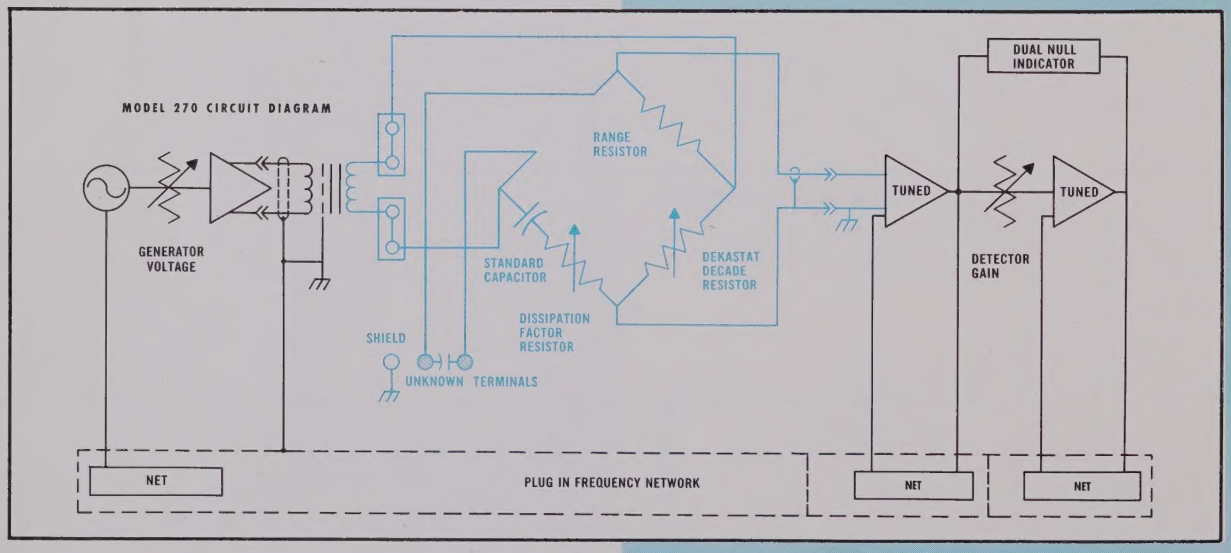
THREE-TERMINAL CAPACITANCE MEASUREMENTS WITH SHIELDED TEST LEAD

MODEL 270 CAPACITANCE BRIDGE

Versatile, Functional Design

Supported by an adjustable wrought-iron stand, the Model 270 Capacitance Bridge can be readily positioned for most convenient operation. When in use, the bridge stand supports the component terminals five inches above the bench or working surface, freeing them from any obstructions. Tilt adjustments can be made for best viewing positions. The wrought-iron legs can be folded back to allow shelf storage of the instrument with a minimum of storage area. When in this position, the wrought-iron stand becomes a carrying handle.





Electro Scientific Industries

7524 S. W. Macadam Avenue • Portland 19, Oregon

formerly **ELECTRO-MEASUREMENTS, INC.**

LITHO IN U.S.A.

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ELECTRO • MEASUREMENTS, INC.
CAPACITANCE BRIDGE
f_{kc} EQUALS
MODEL 270
OSCILLATOR VOLTAGE
OFF
DISSIPATION FACTOR
$\times f_{kc}$
CAPACITANCE
10 mmf
SHIELD

1. INTRODUCTION

The ESI type 270 CAPACITANCE BRIDGE is a portable, self-contained instrument for the rapid and accurate measurement of capacitance. Values of equivalent series capacitance and dissipation factor can be read directly from the dial settings.

The unit consists of an accurate, well-shielded capacitance bridge, including associated generator, detector, and indicator. The case and controls have been human-engineered for maximum accuracy and operator convenience. All the necessary controls are located and clearly identified on the front panel. The adjustable legs permit tilting the instrument to any convenient angle, and can also be positioned to provide a carrying handle.

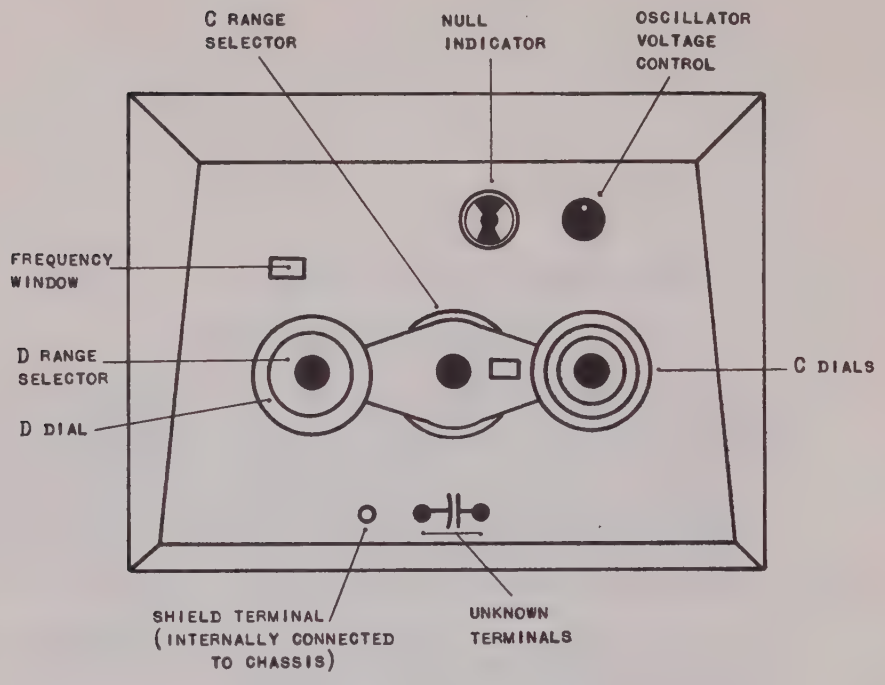
2. OPERATING INSTRUCTIONS

2.1. WHAT THE BRIDGE MEASURES

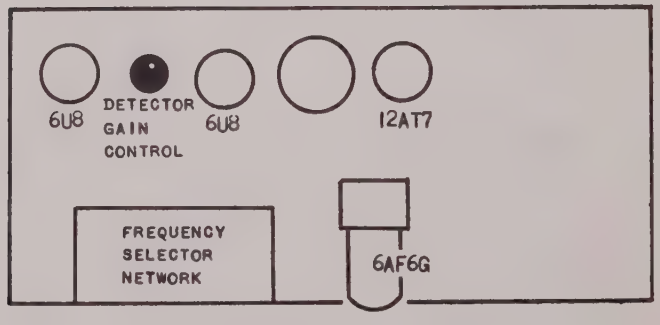
The Model 270 bridge measures "direct" capacitance, with the unknown capacitor connected in an ungrounded arm of the bridge. Stray capacitance and leakage in parallel with the unknown capacitor are eliminated by grounded shielding. This permits the measurement of small three-terminal capacitors to better than 0.01 uuf. without the use of a guard circuit or Wagner ground.

If it is necessary to measure grounded capacitance, the internal connections of the bridge may be changed by means of a special cable assembly.

MODEL 270 PANEL ARRANGEMENT



TOP VIEW OF 270 CHASSIS (COVER RAISED)



2.2. CONTROLS

2.2.1. Frequency Selecting Network

The plug-in unit determines the operating frequency of both the generator and detector.

2.2.2. Dissipation Factor Range Selector

The inner left-hand dial selects from three dissipation factor ranges.

2.2.3. Dissipation Factor (D dial)

The outer left-hand dial indicates the magnitude of the dissipation factor when its indicated value is multiplied by the dissipation factor range selector setting and the frequency in kilocycles.

2.2.4. Capacitance Range Selector

The center dial selects from seven available capacitance ranges.

2.2.5. Capacitance Value Dials (C dials)

The reading of the three dials on the right, multiplied by the capacitance range setting, is the value of the capacitance of the unit connected to the unknown terminals.

2.2.6. Null Indicator

The dual electron ray null indicator provides an extremely broad range of sensitivity. The upper eye responds to large signals and the lower eye responds to very weak signals. A null is indicated by the maximum opening of both eyes.

2.2.7. Unknown Terminals

The unknown terminals have been located below the dials to provide maximum lead accessibility and easy use of the dials without excessive hand capacitance.

2.2.8. Oscillator Voltage Control

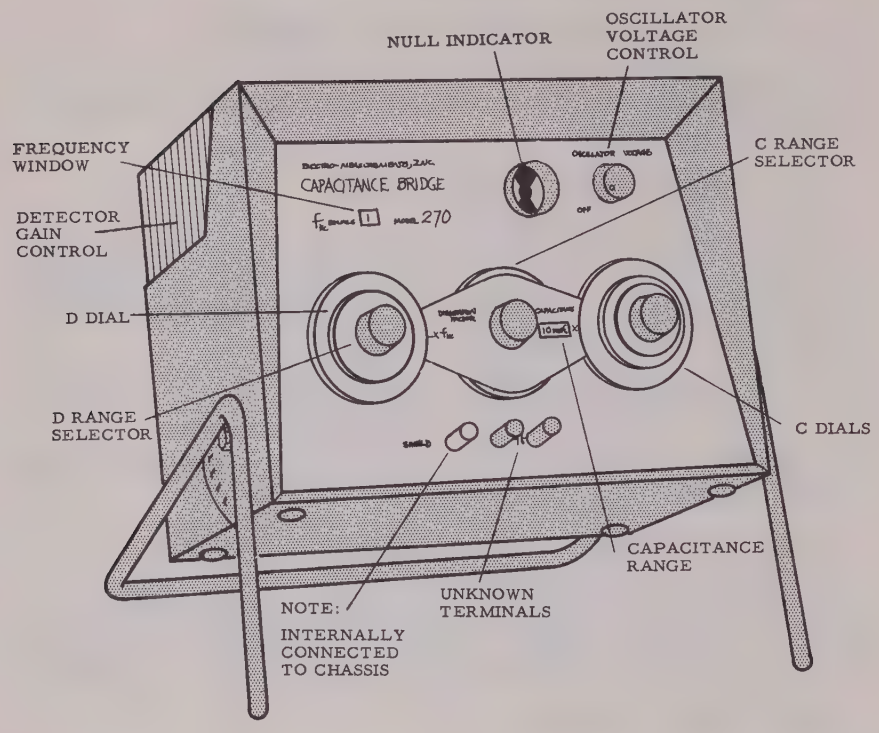
This knob controls the output voltage of the oscillator and operates the external power switch

2.2.9. Detector Gain Control

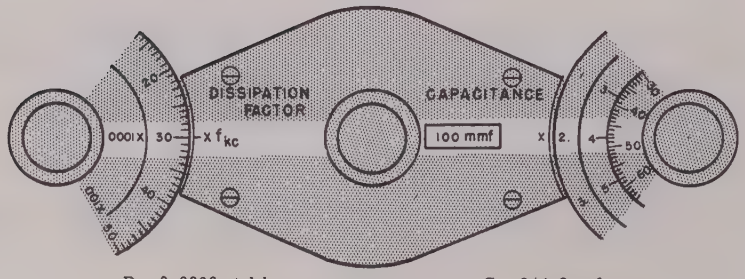
For added flexibility, there is a knob inside the case to adjust the detector gain. Clockwise rotation increases the gain. Where hum pickup is unavoidable, often measurements can be made more easily by reducing the detector gain and increasing the oscillator voltage.

The detector gain control affects only the more sensitive lower half of the eye.

MODEL 270 CAPACITANCE BRIDGE



"IN LINE" READ-OUT



D = 0.0030 at 1 kc

C = 244.8 μμf.

2.3

MEASURING CAPACITANCE

the esi way

2.3.1. Basic Instructions

Connect the capacitor to the UNKNOWN TERMINALS (marked).

Set the OSCILLATOR VOLTAGE control with the dot up.

Set the DETECTOR GAIN CONTROL to maximum. (This control is inside the case and is ordinarily left at maximum.)

Set the D RANGE SELECTOR at .01X.

Set the D DIAL at 0.

Set the C DIALS to read 3.000.

Adjust the C RANGE SELECTOR for maximum opening of the null indicator.

Adjust the C DIALS and the D DIAL alternately for maximum opening of the null indicator.

If additional sensitivity is needed, turn the OSCILLATOR VOLTAGE CONTROL clockwise.

If the C dial reading is less than 1.200, go to the next lower setting of the C range selector.

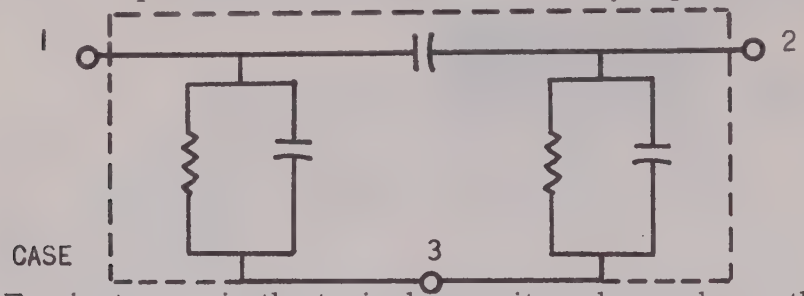
If the D dial reading is less than 10, go to the next lower setting of the D range selector.

The values of series capacitance C and dissipation factor D are as follows:

C = (C range selector setting) x (C dial reading)
D = (D range selector setting) x (D dial reading) x (f_{kc})

2.3.2. Three-Terminal Capacitors

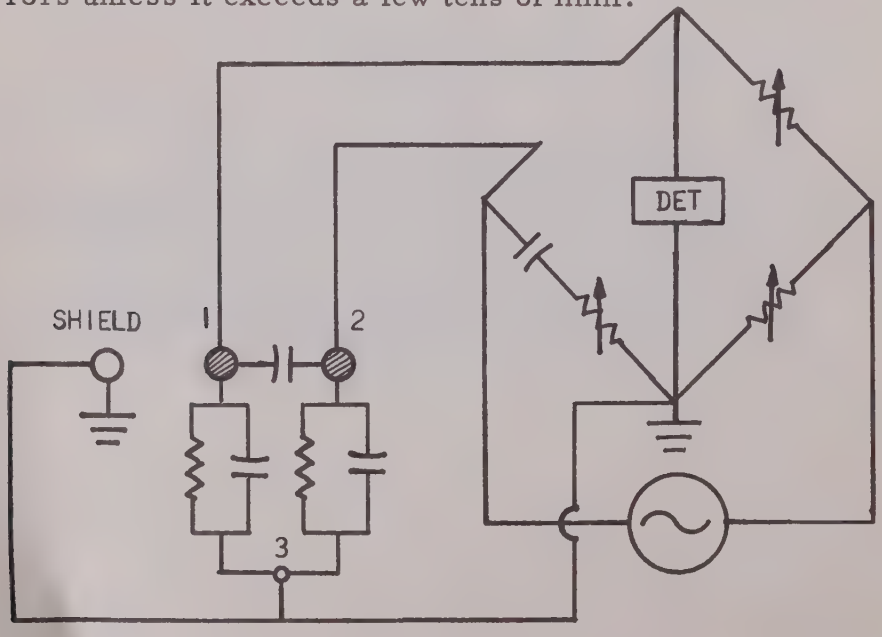
Three-terminal measurements make it possible to measure direct capacitance accurately by isolating the unknown capacitor from the effects of stray capacitances.



For instance, in the typical capacitor shown above, there is stray capacitance from each plate to the case and leakage resistance. With two-terminal techniques, this causes an error in measurement. The bridge reading does not give the capacitance between the plates, but the total impedance of the entire network as seen from terminals 1 and 2

To isolate the direct capacitance, the capacitor case is used as a third terminal and is connected to the shield terminal of the bridge. If one of the stray capacitances is known to be greater, it should be connected from the center terminal to the shield terminal of the bridge. Thus this stray capacitance appears across the detector where it will cause no error. However, large values may reduce the detector sensitivity.

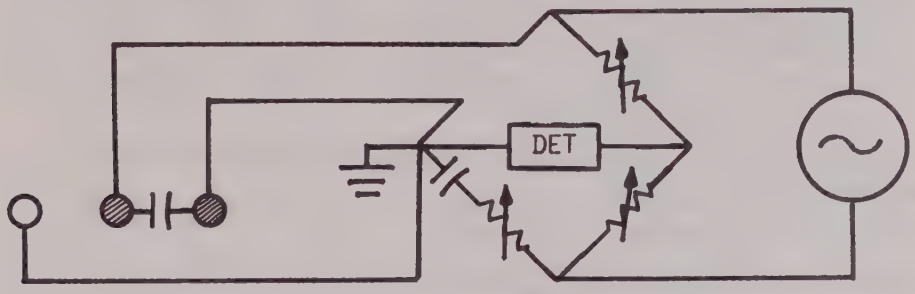
The other stray capacitance is then across the standard capacitor arm of the bridge, in parallel with the standard capacitor. As the standard capacitor is 100,000 mmf, the stray capacitance will not cause significant errors unless it exceeds a few tens of mmf.



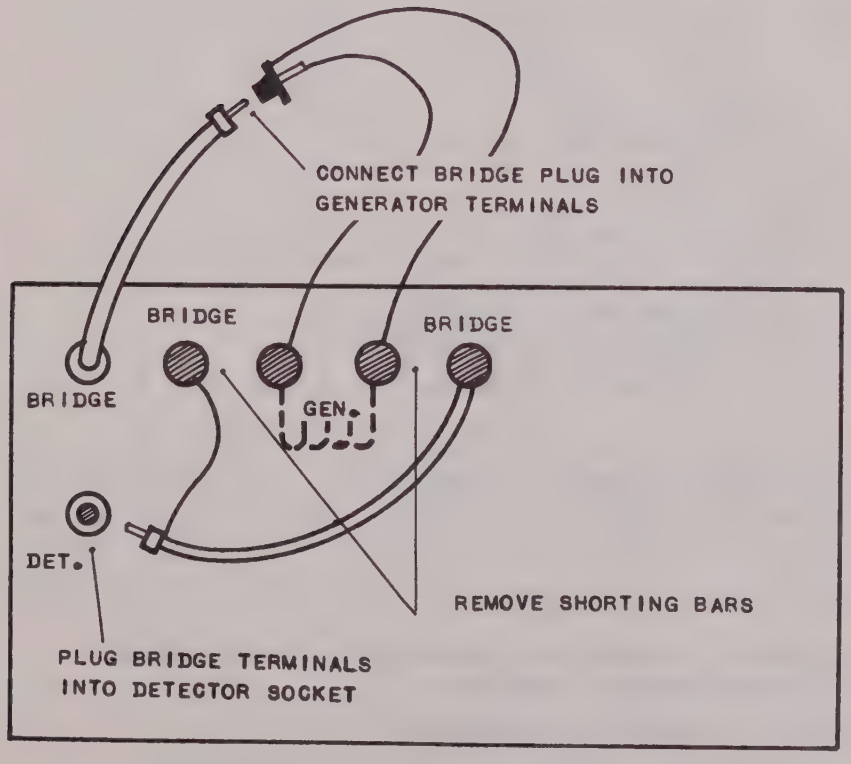
2.3.3. Grounded Capacitance Measurements

Because of inherent errors in making grounded capacitance measurements, the Model 270 Capacitance Bridge has been designed for ungrounded operation. For a grounded measurement several precautions and bridge changes are necessary. In making a grounded measurement the accuracy of the measurement may be reduced.

The generator and detector corners of the bridge must be interchanged. This is done be making the connections shown in the sketches below:



Bridge connections for grounded measurements



Circuit change for grounded measurements
(Top view of bridge with cover raised)

This connection throws nearly 100 mmf of internal capacitance across the unknown terminals of the bridge, so that a zero capacitance measurement is necessary. No appreciable correction will be needed for large capacitances.

2.3.3.1. Procedure:

Make the necessary changes in the bridge circuit.

With nothing connected to the terminals, balance the bridge.

Record these values as C_o and D_o.

Connect the ground side of the capacitor to the right-hand terminal of the bridge.

Connect the other terminal of the capacitor to the center terminal of the bridge.

Balance the bridge.

Record these values as C_m and D_m.

Compute the values of the unknown capacitor, C_x and D_x from the following equations:

For approximate values--

$$C_x = C_m - C_o$$

$$D_x = \frac{C_m D_m - C_o D_o}{C_x}$$

For maximum accuracy--

$$D_x = \frac{C_m D_m (D_o^2 + 1) - C_o D_o (D_m^2 + 1)}{C_m (D_o^2 + 1) - C_o (D_m^2 + 1)}$$

$$C_x = (D_x^2 + 1)\left(\frac{C_m}{D_m^2 + 1} - \frac{C_o}{D_o^2 + 1}\right)$$

2.3.3.2. Expected accuracy:

With grounded connections, the accuracy after calculation is approximately as follows:

$\pm$(1% + 1 mmf)* for capacitance

$\pm$(.001 + 5% of reading) for dissipation factor

2.4. THINGS TO WATCH OUT FOR

2.4.1. Low Capacitance Measurements

In making low capacitance measurements, there are two things to watch out for:

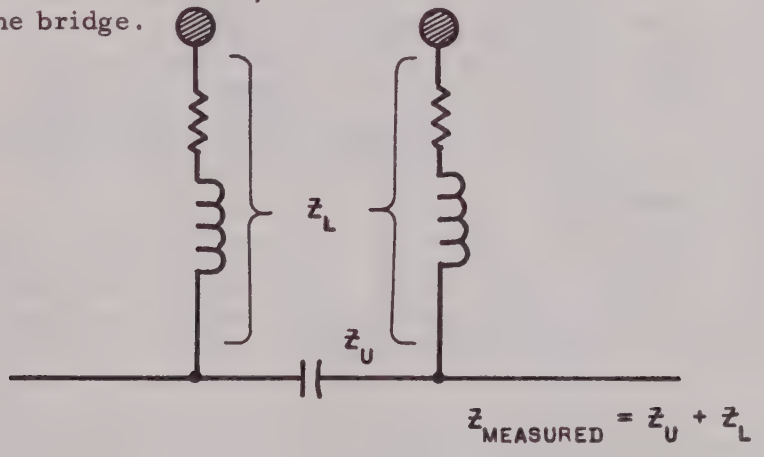
Be careful to avoid hum pickup.
Keep the stray capacitance at a minimum.

To minimize both effects, keep your hands as far as possible from the capacitor being measured.

Keep the leads as short and direct as possible. If extended leads are necessary, the lead from the center terminal should be shielded. See section 2.9., "Extended Leads."

2.4.2. High Capacitance Measurements

The bridge measures the total impedance connected to its terminals. Both the unknown capacitor and its leads contribute to this impedance. The leads have some resistance and inductance, which affect the value read from the bridge.



Z_U = Impedance of unknown capacitor

Z_L = Impedance of leads

For the greatest accuracy, minimize the lead impedance. Short heavy leads will reduce the resistance. Closely-spaced twisted leads will reduce the inductance and the pickup of stray fields.

2.5. POLARIZING VOLTAGE

2.5.1. When to use a Polarizing Voltage

Some capacitors need a polarizing voltage. For example, electrolytic and tantalytic units can be damaged by the reverse polarity half-cycle of the test frequency. Even if the capacitors are not damaged, erroneous readings may result.

2.5.2. When a Polarizing Voltage is Not Necessary

A polarizing voltage is not always needed in these measurements. If the ac voltage is kept at a very low value, the capacitor will not be damaged, and the readings will be reasonably accurate.

Because of the high sensitivity of the Model 270 bridge, accurate measurements can be made with a very low oscillator voltage. When operating with a low oscillator voltage, be sure that the detector sensitivity is maximum.

2.5.3. How to Supply a Polarizing Voltage

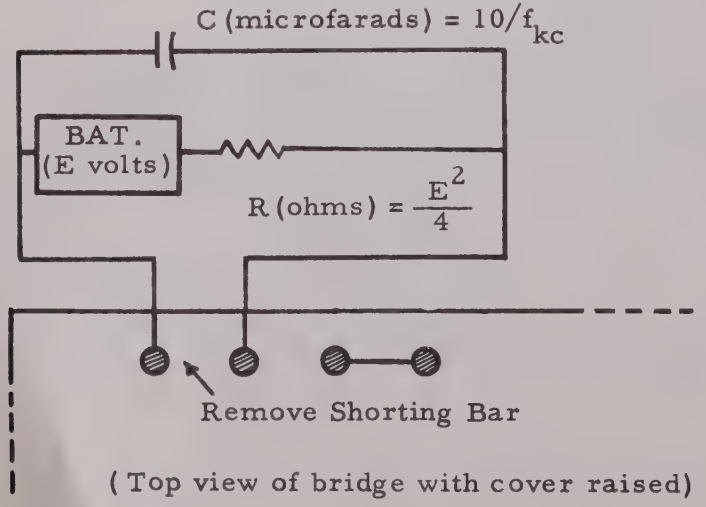
Terminals are provided on each side of the generator transformer for the insertion of a polarizing voltage.

Keep the dc source well insulated, and keep the capacitance to ground as small as possible. Use of a battery is recommended.

The maximum recommended polarizing voltage is 300 v.

The polarizing voltage should be in series with the ac generator. Direct current is then blocked from flowing through the bridge by the unknown capacitor in one arm, and the standard capacitor in the other arm.

The dc source should be by-passed by a capacitor. A current limiting resistor will protect the bridge from damage in case of short circuits.



(Top view of bridge with cover raised)

2.6. VOLTAGE MEASUREMENT

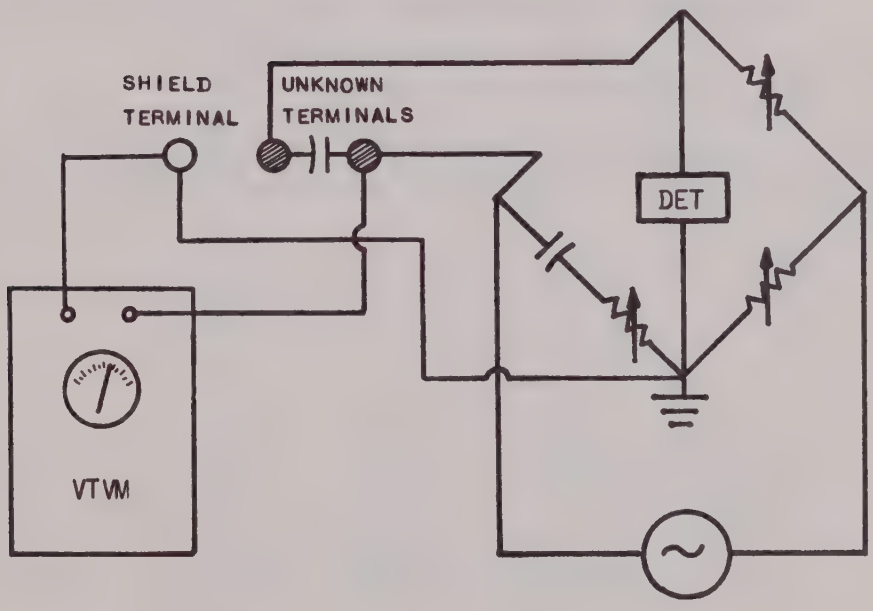
To measure the ac voltage applied across the unknown capacitor:

Connect the ground terminal of a high impedance ac voltmeter to the shield terminal of the bridge.

Connect the input terminal of the voltmeter to the right-hand terminal of the bridge.

Balance the bridge.

Read the voltmeter. With the bridge balanced, this voltage is equal to the ac voltage across the unknown capacitor, but the capacitor has not been loaded by the voltmeter. The bridge readings, however, may be incorrect while the meter is connected.



2.7. EQUIVALENT SERIES RESISTANCE AND STORAGE FACTOR

The bridge measures effective series capacitance and dissipation factor. From these values, storage factor and equivalent series resistance can be calculated.

$$Q = \frac{1}{D}$$

$$R_s = \frac{D}{2\pi f C_s}$$

Q = Storage factor

R_s = Equivalent series resistance, in kilohms

D = Measured dissipation factor

C_s = Measured equivalent series capacitance, in mf

f = Frequency, in kilocycles

2.8. EQUIVALENT PARALLEL CIRCUIT

From the equivalent series capacitance and dissipation factor measured, the equivalent parallel circuit can be derived.

$$Q = \frac{1}{D}$$

$$C_p = \frac{C_s}{1 + D^2}$$

$$R_p = \frac{1 + D^2}{D^2} R_s = \frac{1 + D^2}{D} \frac{1}{2\pi f C_s}$$

Q = Storage factor

C_p = Equivalent parallel capacitance, in mf

R_p = Equivalent parallel resistance, in kilohms

D = Measured dissipation factor

C_s = Measured equivalent series capacitance, in mf

R_s = Equivalent series resistance, in kilohms

f = Frequency, in kilocycles

The D of the equivalent parallel circuit always equals the D of the equivalent series circuit. The same is true of Q.

2.9. EXTENDED LEADS

Sometimes it is necessary to use extended leads. This can be done easily, without causing error in the measurement.

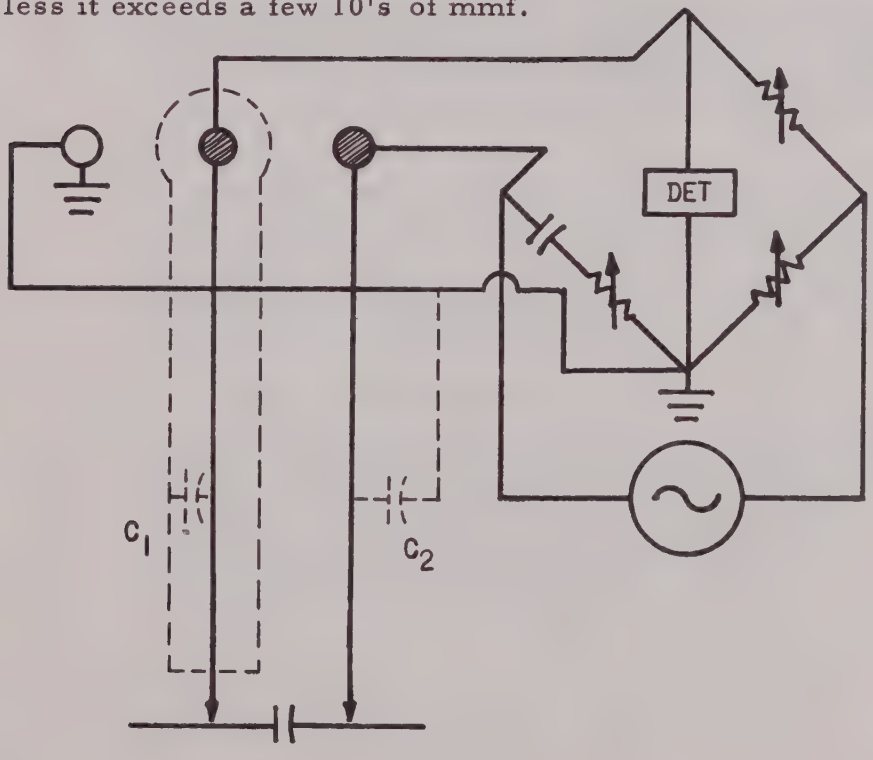
Connect a shielded lead to the center terminal.

Connect the shield of this lead to the shield terminal of the bridge.

Connect an ordinary clip lead to the right-hand terminal.

The capacitance between the shield and the center conductor is now across the detector. This keeps it from causing any error. If this stray capacitance is greater than 500 mmf, it may reduce the detector sensitivity.

The stray capacitance from the unshielded lead to ground is across the standard capacitance arm of the bridge. As the standard capacitor is 100,000 mmf, the stray capacitance will not cause significant errors unless it exceeds a few 10's of mmf.



C_1: Capacitance from center conductor to ground

C_2: Capacitance from unshielded conductor to ground

3. SPECIFICATIONS

Capacitance Range:

0 to 120 microfarads in 7 ranges

0.01 micromicrofarad per dial division on the lowest range

Accuracy: ±(0.20% + 1 dial division). Slightly larger errors may be encountered on the highest and lowest capacitance ranges.

Dissipation Factor Range at 1 kc:

0 to 1.05 in 3 ranges

0.0001 per dial division on lowest range

Accuracy: ±(0.0005 + 2% of the reading). Slightly larger errors may be encountered on the highest and lowest capacitance ranges.

4. MAINTENANCE

4.1. AMPLIFIER-OSCILLATOR SECTION

Keep printed circuit board free of accumulations of dust and dirt.

Check vacuum tubes approximately every 5,000 hours of operation.

Replace null-indicating eye tube (6AF6G) whenever shadow pattern shows inadequate contrast against fluorescent background.

4.2. BRIDGE SECTION

4.2.1. Cleaning of Slide-Wire Rheostat

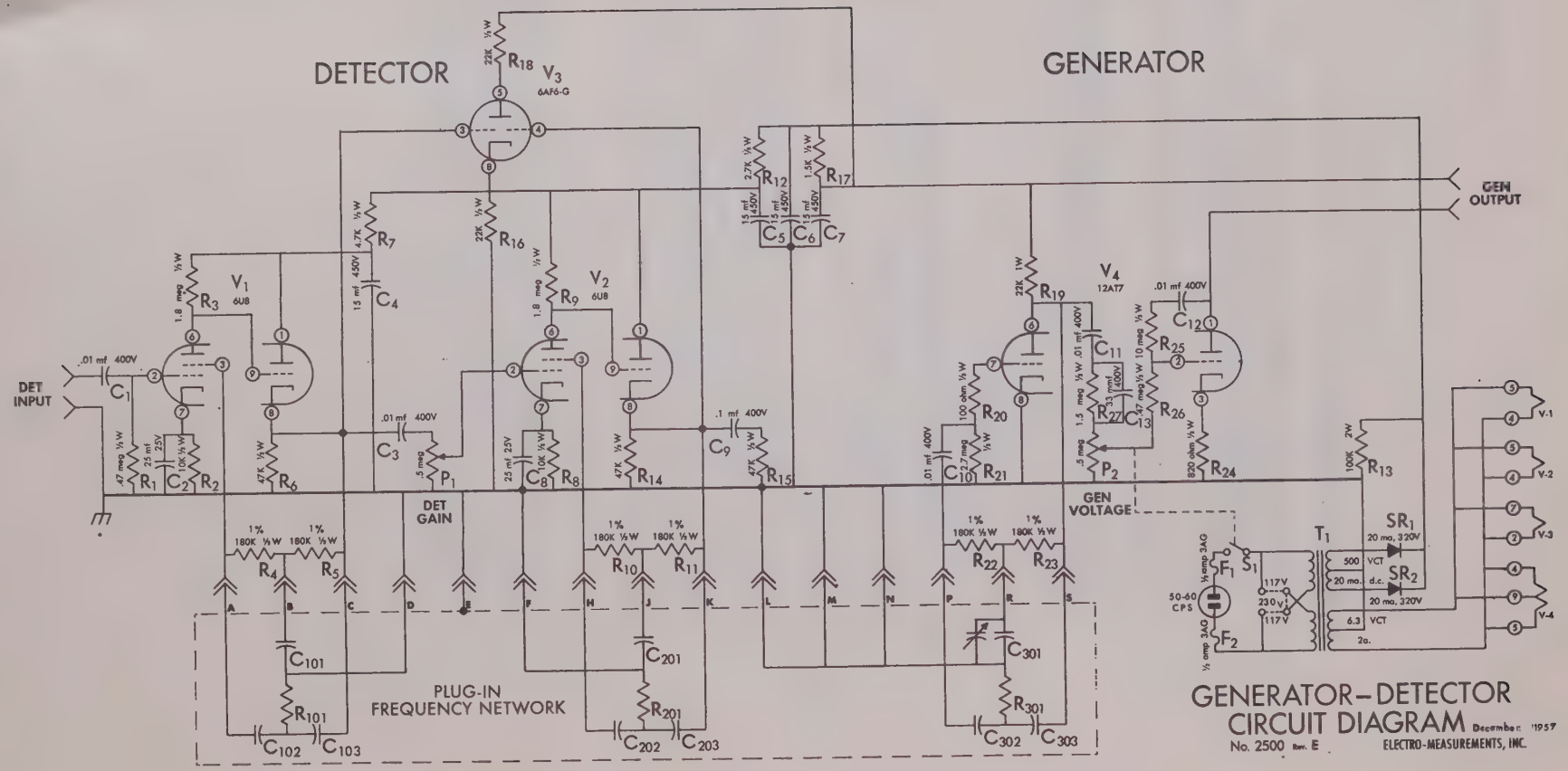
Remove rear bridge cover.

Remove DEKASTAT dust cover. Follow instructions on dust cover.

Using a small strip of crocus cloth, wipe both slide wires. Make two or three continuous rotations. Care should be taken to rotate the slider out of the way to avoid changing its contact force. To complete cleaning, wipe slide-wires and contacts with a clean, dry, lint-free cloth to remove loose particles.

4.2.2. Adjusting Slide-Wire Rheostat

It is recommended that instrument be returned to factory if slide-wire contacts require adjustment. Where it is absolutely necessary to make repairs yourself, adjust each slider so that contact force measures 75 to 100 grams. USE EXTREME CAUTION to avoid damaging slide-wires.



GENERATOR–DETECTOR CIRCUIT DIAGRAM

December 1957

No. 2500 Rev. E

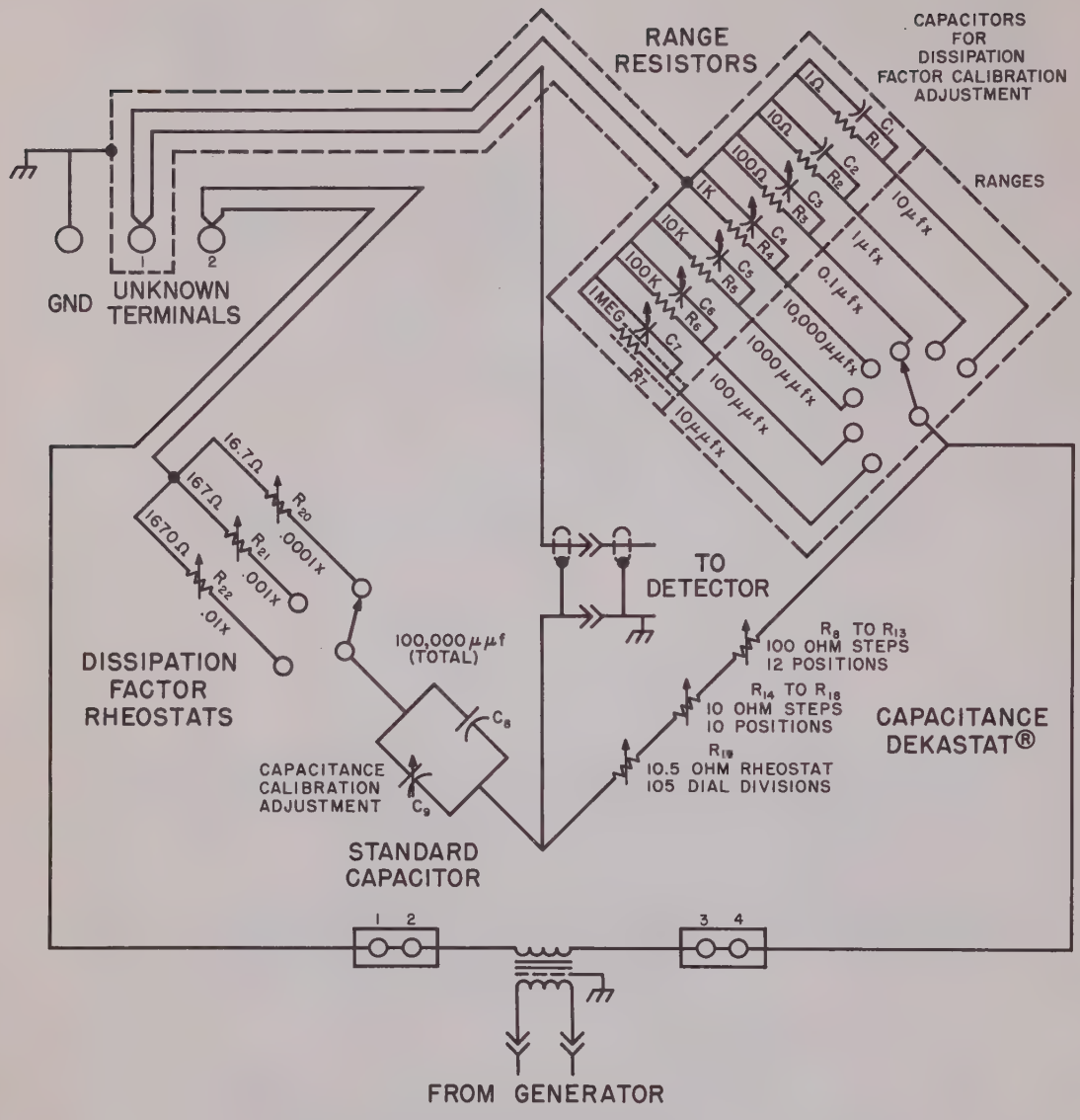
ELECTRO-MEASUREMENTS, INC.

GENERATOR DETECTOR COMPONENT PARTS

R-1	470K	10%	1/2W
R-2	10,000Ω	10%	1/2W
R-3	1.8 meg	10%	1/2W
R-4	180K	1%	1/2W
R-5	180K	1%	1/2W
R-6	47,000Ω	10%	1/2W
R-7	4,700Ω	10%	1/2W
R-8	10,000Ω	10%	1/2W
R-9	1.8 meg	10%	1/2W
R-10	180K	1%	1/2W
R-11	180K	1%	1/2W
R-12	2,700Ω	10%	1/2W
R-13	100K	10%	2W
R-14	47,000Ω	10%	1/2W
R-15	47,000Ω	10%	1/2W
R-16	22,000Ω	10%	1/2W
R-17	1,500Ω	10%	1/2W
R-18	22,000Ω	10%	1/2W
R-19	22,000Ω	10%	1W
R-20	100Ω	10%	1/2W
R-21	2.7 meg	10%	1/2W
R-22	180K	1%	1/2W
R-23	180K	1%	1/2W
R-24	820Ω	10%	1/2W
R-25	10 meg	10%	1/2W
R-26	470K	10%	1/2W
R-27	1.5 meg	10%	1/2W
F-1, F-2	1 amp		3 AG

SR-1, SR-2		20 ma, 320V Selenium rectifier
V-1	6U8A	
V-2	6U8A	
V-3	6AF6-G	
V-4	12AT7	
P-1	500K	10% 2W
P-2	500K	10% 2W
S-1	SPST	2A 125V
T-1	500VCT	20 ma. d.c.
	6.3VCT	2a.

C-1	0.01 µf	±20%	400V
C-2	25 µf		25V
C-3	0.01 µf	±20%	400V
C-4	15-15-15-15 µf		450V
C-5	15-15-15-15 µf		450V
C-6	15-15-15-15 µf		450V
C-7	15-15-15-15 µf		450V
C-8	25 µf		25V
C-9	0.1 µf	±20%	400V
C-10	0.01 µf	±20%	400V
C-11	0.01 µf	±20%	400V
C-12	0.01 µf	±20%	400V
C-13	33 µµf	5%	400V



5.1 MODEL 270 CAPACITANCE BRIDGE CIRCUIT DIAGRAM

esi®

Precision Products

Bridges and Accessories

Decade Voltage Dividers

Decade Resistors

Decade Capacitors

ESIAC Computers

Electro Scientific Industries

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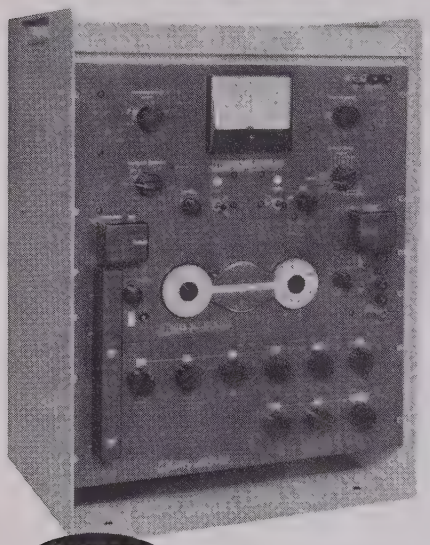
esi **Precision** SYSTEMS FOR



Accuracy ± 0.01%

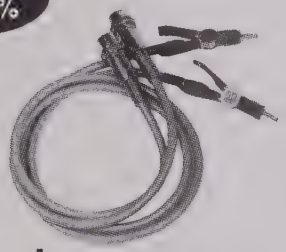
The Measurement System Concept

To attain the accuracy and precision of measurement demanded by modern science and technology requires much more than a precise and reliable measurement instrument.

Accurate measurements also require a judicious combination of (1) basic measurement techniques (2) the implementation of these techniques by carefully chosen instrumentation and (3) the availability of adequate reference standards to calibrate the instrumentation.

Intelligent selection of such parameters as impedance levels, operating voltages and frequencies, detector sensitivities and selectivity and connection methods can insure maximum accuracy throughout a chain of measurements. Properly employed, this chain can be extended to provide direct traceability to reference standards certifiable by the National Bureau of Standards. Specialized transfer standards can be used to simplify the chain and enhance both the accuracy and speed of measurements.

This is the measurement system concept—the integration of design, instrumentation and "state-of-the-art" metrology techniques to provide incisive tools for precise electrical measurements. These ESI measuring systems are specifically designed to meet the demanding requirements of this concept.



KELVIN KLIPS:
4 terminal measurement accessory

Kelvin Klips originally designed for the ESI Model 242 system—now available for making rapid, precision four-terminal resistance measurements even with relatively high lead and contact resistances. Kelvin Klips also provide a strong reliable low resistance, long life, all-purpose test clip for two-terminal applications. Price $7.50 for Klips only, or $25.00 assembled with shielded cable and spade lug terminations. Request Catalog Sheet C-31.

MODEL 242 RESISTANCE MEASURING SYSTEM

A precision resistance bridge of wide range, superior accuracy and extreme resolution. Compares the percentage difference between the unknown resistance and the product of the standard resistance times the multiplier. Bridge multiplier accurate to better than ±0.005%. Comparisons to an accuracy of 1 ppm are possible by using substitution techniques. Measurements of ±0.01% accuracy can be made directly without calibration and with no need for zero resistance or lead resistance correction. With a set of Model SR-1010 Resistance Transfer Standards, measurements over a wide resistance range are traceable to an NBS certified standard with an accuracy of a few ppm.

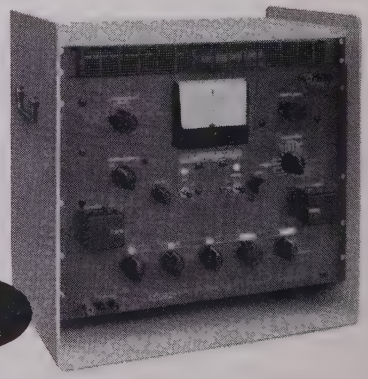
242—Resistance Measuring System—Ratio bridge, decade standard, and generator-detector in case with Kelvin Klips	$3,400.00*
241—Resistance Comparison System—Ratio bridge and generator-detector in case	2,300.00*
243—Ratio bridge and decade standard in case	2,200.00*
240—Kelvin Ratio Bridge (Less Accessories)	900.00*
800—DC Generator-Detector	1,300.00*
RS-925—Decade Resistance Standard—0.01 ohm to 1.2 megohm, with 0.0001 ohm resolution in four-terminal connection	1,200.00*
SR-1010—Resistance Transfer Standards (See separate description on Standards page) each	250.00*

Request Catalog Sheet C-27 and Design Ideas Volume 1, 2 and 3.

MODEL 231-A GUARDED WHEATSTONE RESISTANCE MEASURING SYSTEM

A precision, high resolution Wheatstone bridge. Five place readings; initial accuracy of ±0.005%, long term accuracy ±0.01%. Human engineered for simple operation and direct readout. Automatic decimal point location. Internal guarding permits accurate, high resolution measurements to 12 kilomegohms. Matching generator-detector provides 6 output ranges to match loads from 1 ohm to 100 kilohms. Mounted in attractive, rugged case.

231-A–Resistance Measuring Assembly (With Accessories)	$1,875.00*
230-A—Guarded Resistance Bridge (Less Accessories)	450.00*
800—Generator-Detector	1.300.00*



Accuracy ± 0.01%

For Further Information Request Catalog Sheet C-21.

***All prices f.o.b. Portland, Oregon.**

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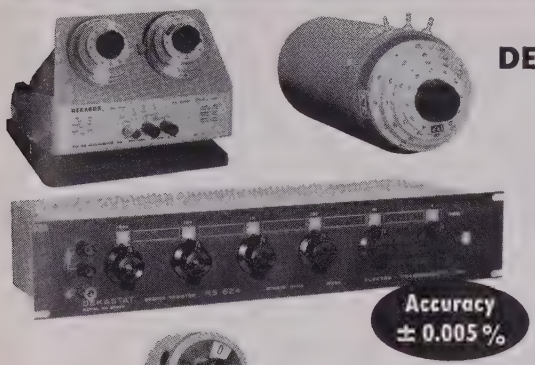
Decade Units

esi®



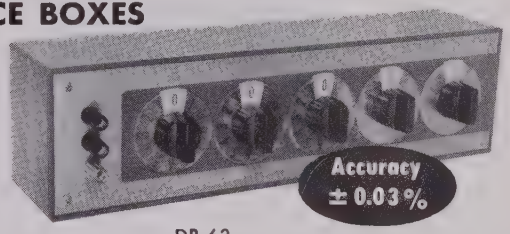
DEKASTAT® and DEKABOX® DECADE RESISTORS

Adjustable resistance standards of high accuracy containing one or more decades of precision fixed resistors. Some models include an interpolating rheostat. Accuracies to 0.005% initial, 0.02% long term. Temperature coefficient less than ± 5 ppm per degree Centigrade. Model DS Dekastat for panel mounting. Model DB Dekabox for bench use, Model RS Dekastat for rack mounting.

Prices: from $63.00 to $550.00*

For Further Information Request Catalog Sheet C-18.

DEKABOX®
IN-LINE DECADE RESISTANCE BOXES



Units may be obtained with four, five, and six decades with resolutions from 10 milliohms per step.

Individual resistors of 100 ohms and above have a temperature coefficient of 10 ppm/°C. and resistors below 100 ohms 20 ppm/°C. Accuracy of adjusment of decades is ± (0.03% + 1 milliohm/decade.) Total zero resistance of each box is 10 milliohms.

The units are offered with total resistance values from 111.1 ohms to 11.11110 megohms.

Steps	DB-42 4 dials	DB-52 5 dials	DB-62 6 dials
0.01 Ω	111.1 Ω $125.00	1.11110 K $150.00	11.11110 K ...$175.00
0.1 Ω	1.1110 K $100.00	11.1110 K $125.00	111.1110 K ...$150.00
1 Ω	11.110 K 100.00	111.110 K 125.00	1.111110 meg . 160.00
10 Ω	111.100 K 100.00	1.11110 meg . 135.00	11.11110 meg . 195.00
100 Ω	1.111000 meg . 110.00	11.1110 meg .. 170.00	.....
1 K	11.11000 meg . 145.00	.....	.....

above prices f.o.b. Portland, Oregon

DEKAPACITOR® and DEKABOX® DECADE CAPACITORS

Adjustable, low loss decade units. Hermetically sealed polystyrene capacitors except below 1000 picofarads where high quality ceramic or mica capacitors are used. Accuracy 1%. Model DK-30 Dekapacitor for panel mounting. Model DC-40 Dekabox for bench use.

DK-30: 1μf—3 decades, for panel mounting. Price: $200.00*

DC-40: 1μf—4 decades, bench mount. Price: $240.00*

For Further Information Request Catalog Sheet C-18.

DEKAPOT® DECADE VOLTAGE DIVIDERS

The Dekapot contains one or more resistive Kelvin-Varley decades and an interpolating potentiometer to provide high resolution and accurate voltage divisions. They are designed for panel mounting and utilize the exclusive ESI Dekadial concentric dials for direct in-line readout. Linearity from ±0.1% to ±0.005%. Price: from $69.00 to $175.00*

MODEL DP-451—A militarized version of the ESI Model DP-211. Certified to meet the environmental test requirements of MIL-T-945A. The electrical specifications are identical to that of the DP-211. Standard values: 1K, 10K, and 100K. Price: from $145.00 to $160.00*

For Further Information Request Catalog Sheet C-23.

***All prices f.o.b. Portland, Oregon. Quantity discounts available.**

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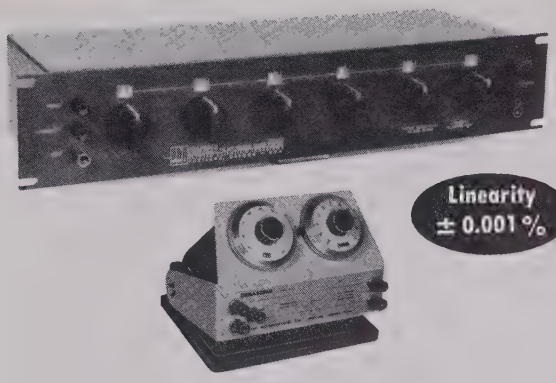
Dividers AND Networks



DEKAVIDER® DECADE VOLTAGE DIVIDERS

Resistive voltage dividers using the Kelvin-Varley circuit.

In-line control knobs on the rack mounted divider and the exclusive ESI Deka-dial® coaxial dial of the bench mounted unit simplify dial settings and permit easy in-line readings. For use from dc through audio frequencies.

RV-622A: precision resistors closely matched for maximum accuracy. Linearity 10 ppm, resolution 0.0001%. 10K Price: $450.00*
100K Price: $500.00*

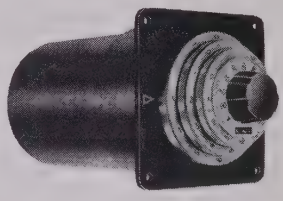
DV-411: linearity 50 ppm, resolution 0.0003%. Price: $145.00 *

For Further Information Request Catalog Sheet C-23.

DEKATRAN DECADE TRANSFORMERS

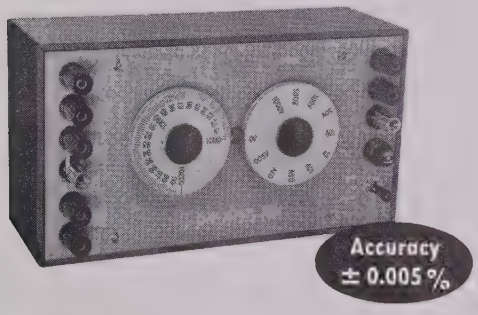
Decade transformers providing exceptional accuracy over a wide range of environmental conditions.

MODEL DT-45: three decades plus an interpolating potentiometer give accurate five-place readings of voltage ratio (linearity and resolution to 10 ppm).



MODEL DT-35: two decades plus an interpolating potentiometer give accurate four-place readings (linearity and resolution to 100 ppm). All units designed for panel mounting. Price: DT-35, $160.00*; DT-45, $265.00*

For Further Information Request Catalog Sheet C-22 (DT-45); C-24 (DT-35).



MODEL SV-194B VOLTAGE CALIBRATOR

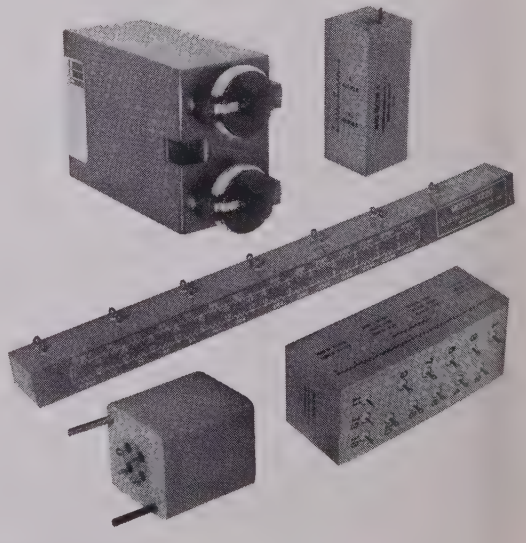
A precision divider for calibrating potentiometric dc voltmeters. Alternate techniques can be used for checking the accuracy of other types of voltmeters, power supplies and standard cells. Inputs of 1000 and 500 volts; outputs 1000, 500, 100, 50, 10, 5, 1.0, 0.5, 0.1, 0.05 and 0 volts. A calibration certificate is supplied, specifying calibration data accuracy to ±0.005%. Price: $250.00*

For Further Information Request Catalog Sheet C-26.

CUSTOM RESISTOR NETWORKS

High precision custom resistor networks are available to meet specific requirements. The resistors used are wound with wire which has a temperature coefficient less than ± 2 ppm per degree Centigrade, and are adjusted to extremely close tolerance after being put through a special aging process. The ruggedness and stability of ESI resistors makes them suitable for networks for field use, under difficult environmental test conditions. In laboratory applications, accuracies similar to those of ESI standard resistors can be supplied. In order to assure high reliability and accuracy, ESI networks are sold only mounted in suitable enclosures. ESI custom networks represent the solution to problems in temperature coefficient matching and special packaging.

Individual quotations will be made upon request.



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Computers AND Services

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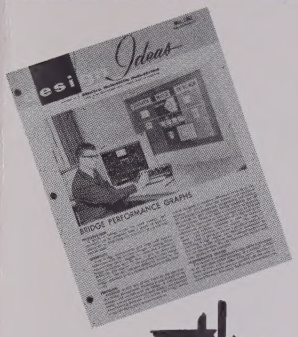


QUARTERLY TECHNICAL PUBLICATION—"DESIGN IDEAS"

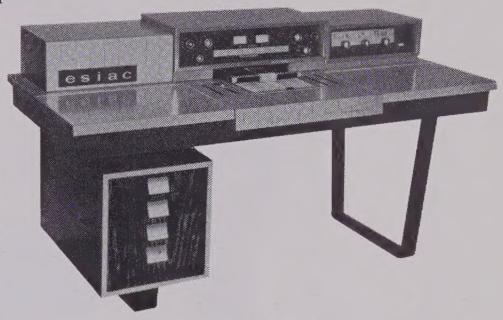
ESI publishes a quarterly release called "Design Ideas." Its purpose is to inform our customers of advanced techniques and applications in the field of precision measurements. It also indicates ESI's progress in applying these techniques to development of "state of the art" equipment and procedures. Issues published covered such subjects as voltage divider calibration, precision resistance measurements and bridge performance graphs. The publications are mailed without charge upon request.

the esiac®

A NEW APPROACH TO SYSTEM DESIGN

The Model 10 ESIAC ALGEBRAIC COMPUTER calculates solutions for the characteristic equations of circuits and control systems. The results are presented as root-locus plots and Bode phase and gain diagrams. The root locus technique is used to find closed loop response from open loop data for feedback controlled systems and it is also used for factoring polynomials. Bode plots present frequency response in terms of gain and phase shift.

Rapid pole-zero programming allows the ESIAC user to study quickly the effect of changes in system parameters or components. For example, the poles and zeros of a compensating network can be added to correct an unstable system. The results can be analyzed by a new root-locus plot in a matter of minutes. The ESIAC provides a "feel" of the system that no other computer can equal.



Solves intricate system design problems in minutes instead of hours, hours instead of days. Write on your company letterhead for new 30-page brochure on theory, operation, advantages and typical, problem-solving appliactions of the ESIAC algebraic computer in dynamic systems design.

TALK TO AN ESI ENGINEER — AT NO COST TO YOU

Any questions? Use your phone. Get the answers fast, accurately, first-hand from an ESI applications engineer at the factory. The numbers below are listed in your local directory. No long distance charges. Dial operator—ask for:

NEW ENGLAND & MIDDLE ATLANTIC

Wilmington, Del.	Enterprise 1-0384
Baltimore, Md.	Enterprise 9-3350
Andover, Mass.	Enterprise 3331
Boston, Mass.	Enterprise 3331
Cambridge, Mass.	Enterprise 3331
Lexington, Mass. (Including Bedford)	Enterprise 3331
Pittsfield, Mass.	Enterprise 3331
Waltham, Mass.	Enterprise 3331
Wayland, Mass.	Enterprise 3331
Wilmington, Mass.	Enterprise 3331
Camden, N. J.	WX 6619
Eatontown, N. J.	WX 6619
Hasbrouck Heights, N. J.	WX 6619
Jersey City, N. J.	WX 6619
Little Falls, N. J.	WX 6619
Long Branch, N. J.	WX 6619
Newark, N. J.	WX 6619
New Brunswick, N. J.	WX 6619
Passaic, N. J.	WX 6619
Paterson, N. J.	WX 6619
Plainfield, N. J.	WX 6619
Princeton, N. J.	WX 6619
Ridgewood, N. J.	WX 6619
Summit, N. J.	WX 6619
Unionville, N. J.	WX 6619
Whippany, N. J.	WX 6619
Bronx, N. Y.	Enterprise 6619
Brooklyn, N. Y.	Enterprise 6619
Buffalo, N. Y.	Enterprise 6619
Endicott, N. Y.	Enterprise 6619
Ithaca, N. Y.	Enterprise 6619
Kingston, N. Y.	Enterprise 6619
Manhattan, N. Y.	Enterprise 6619
Nassau County, N. Y.	Enterprise 6619
Owego, N. Y.	Enterprise 6619
Peekskill, N. Y.	Enterprise 6619
Poughkeepsie, N. Y.	Enterprise 6619
Queens, N. Y.	Enterprise 6619
Rome, N. Y.	Enterprise 6619
Schenectady, N. Y.	Enterprise 6619
Southern Westchester, N. Y.	Enterprise 6619
Staten Island, N. Y.	Enterprise 6619
Syracuse, N. Y.	Enterprise 6619
Utica, N. Y.	Enterprise 6619
Philadelphia, Pa.	Enterprise 6619
Washington, D. C.	Enterprise 1-3331

SOUTH EASTERN

Huntsville, Ala.	WX 1000
Orlando, Fla.	WX 1000
Atlanta, Ga.	WX 1000
Burlington, N. C.	WX 1000

NORTH CENTRAL

Chicago, Ill.	Enterprise 5225
Indianapolis, Ind.	Enterprise 3331
Detroit, Mich.	Enterprise 7779
Minneapolis, Minn.	Zenith 3331
Kansas City, Mo.	Enterprise 8675
St. Louis, Mo.	Enterprise 8675
Cleveland, Ohio	Enterprise 3331
Dayton, Ohio	Enterprise 3331
Pittsburgh, Pa.	Zenith 0619
Milwaukee, Wis.	Enterprise 3331

WESTERN

Phoenix, Ariz.	Zenith 675
Tucson, Ariz.	Enterprise 675
Belmont, Calif.	Enterprise 1-3031
Berkeley, Calif.	Enterprise 1-3031
Burbank, Calif.	Zenith 9-1088
Culver City, Calif.	Zenith 9-1088
Downey, Calif.	Zenith 9-1088
East Bay, Calif.	Enterprise 1-3031
El Segundo, Calif.	Zenith 9-1088
Folsom, Calif.	Enterprise 1-3031
Glendale, Calif.	Zenith 9-1088
Hawthorne, Calif.	Zenith 9-1088
Inglewood, Calif.	Zenith 9-1088
Livermore, Calif.	Enterprise 1-3031
Los Angeles, Calif.	Zenith 9-1088
North Hollywood, Calif.	Zenith 9-1088
Mt. View, Calif.	Enterprise 1-3031
Palo Alto, Calif.	Enterprise 1-3031
Pasadena, Calif.	Zenith 9-1088
Redwood City, Calif.	Enterprise 1-3031
Sacramento, Calif.	Enterprise 1-3031
San Carlos, Calif.	Enterprise 1-3031
San Diego, Calif.	Zenith 1088
San Francisco, Calif.	Enterprise 1-3031
San Jose, Calif.	Enterprise 1-3031
San Matéo, Calif.	Enterprise 1-3031
Sunnyvale, Calif.	Enterprise 1-3031
Torrance, Calif.	Zenith 9-1088
Van Nuys, Calif.	Zenith 9-1088
Denver, Colo.	Enterprise 3331
Idaho Falls, Ida.	Enterprise 675
Albuquerque, N. M.	Enterprise 675
Salt Lake City, Utah	Zenith 711
Renton, Wash.	Zenith 9351
Richland, Wash.	Zenith 9351
Seattle, Wash.	Zenith 9351

If your area is not listed above, call us collect—**CH 6-3331,** Portland, Oregon

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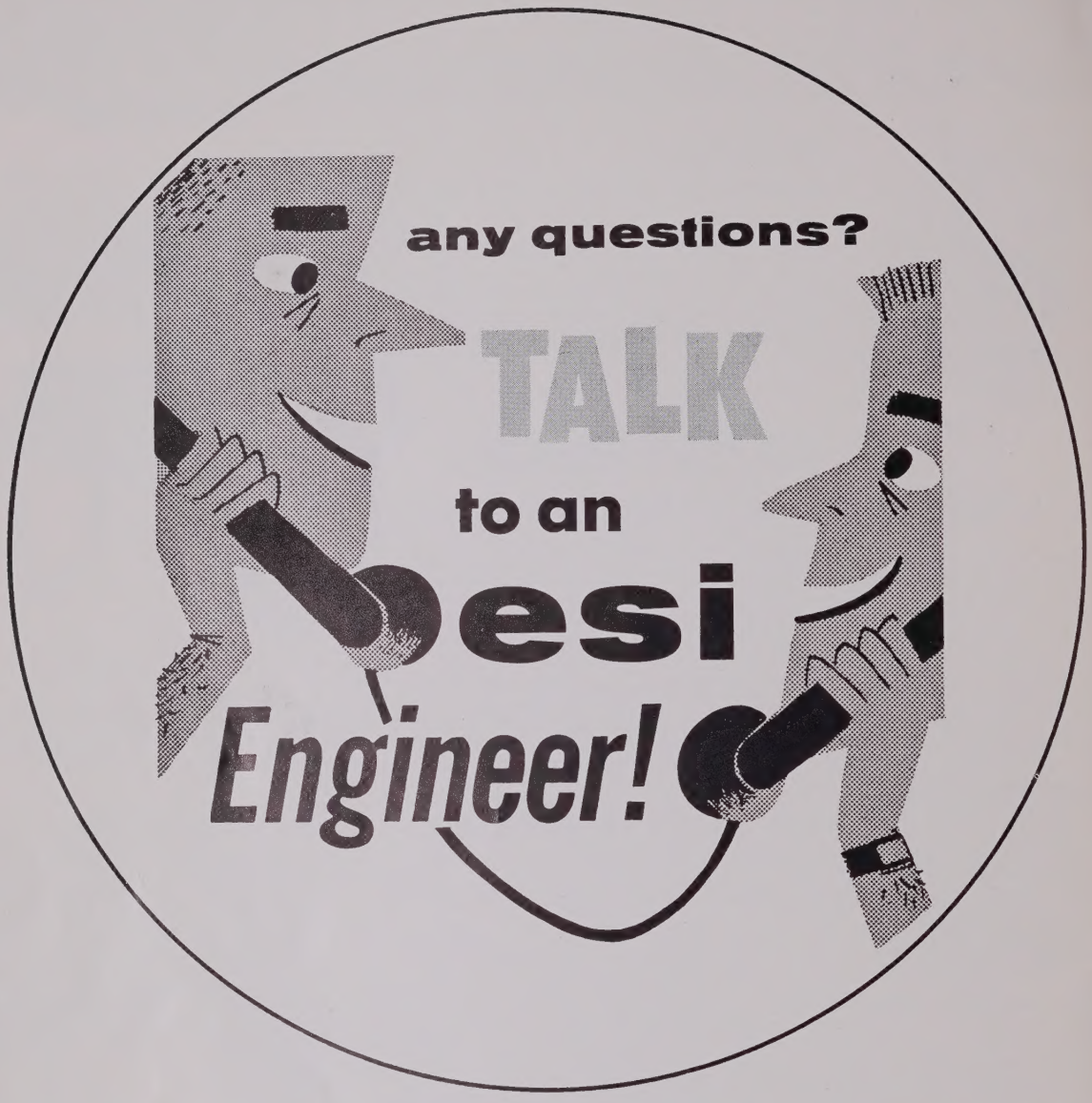

WORLD'S LARGEST DIRECT TELEPHONE NETWORK

To better serve you, ESI now maintains local directory listings in all principal marketing areas throughout the nation.

These numbers provide direct, toll-free telephone service to our plant in Portland and to our special engineering sales-service department.

Staff members are specialists in the electronic measurements field, thoroughly familiar with ESI products and applications. Their technical knowledge and engineering skills are available to you as quickly and conveniently as calling across town or to the next office.

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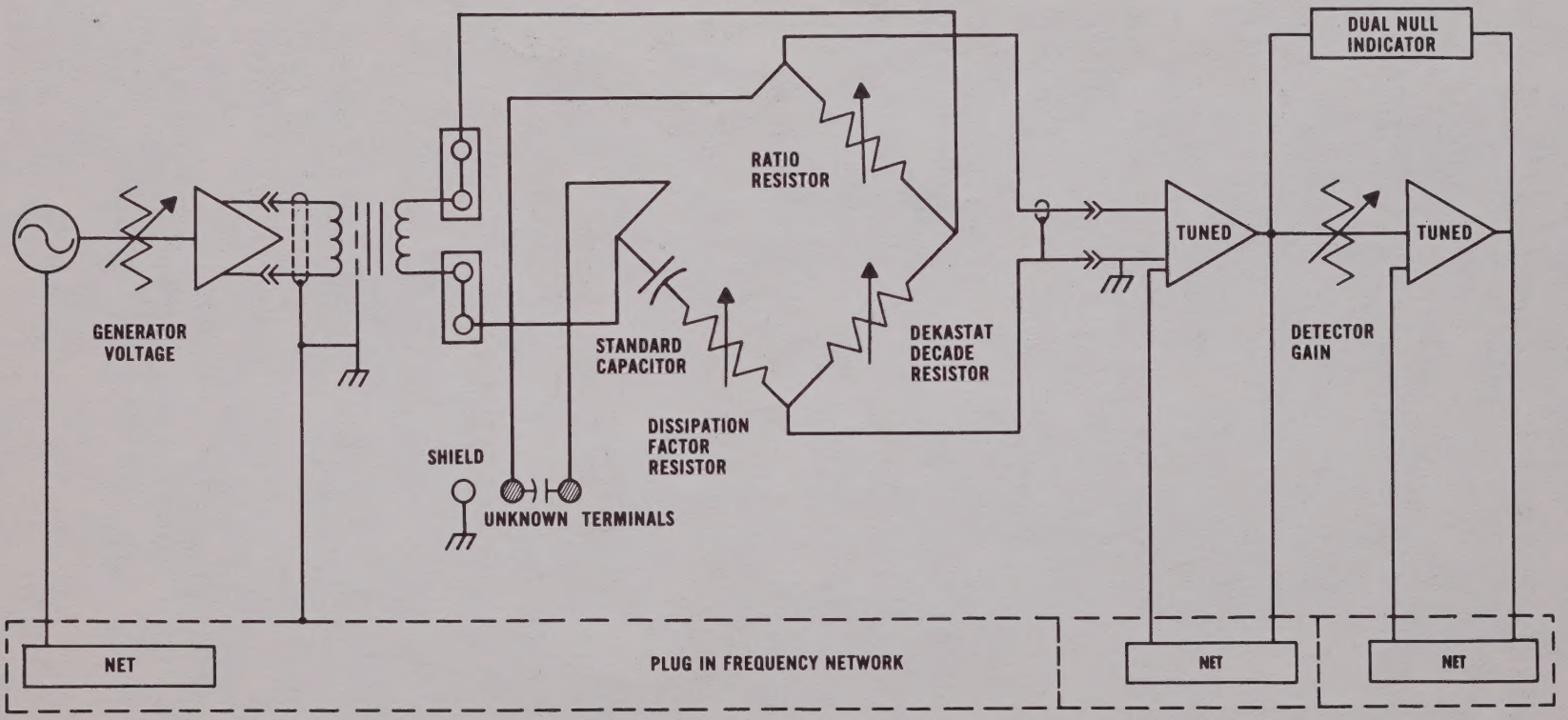

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